Design Notes for the DMTD Mixer Module

1. The circuits for the reference and measurement sections are essentially identical.
2. The RF signal inputs have isolation transformers and isolated returns to reduce ground loop interference. The LO signals use the local ground, which is partially separated between the two sections.
3. The RF input signals have level adjustments to set the output of the 1st IF amplifier to the largest possible sinusoidal swing.
4. The RF and LO signals are buffered by isolation amplifiers to provide a well-defined 50 ohm input impedance, a well-defined 50 ohm source impedance for the mixer, and to reduce reverse coupling of mixer intermodulation components back into the RF or LO source. LMH6607 devices are shown, but the wider-bandwidth LMH6703 can be used instead, and may provide better phase stability, and would support higher gain by increasing the value of R3 and R24.
5. The mixers are ordinary double-balanced diode mixers, terminated into a capacitive load and followed by a low-pass filter to remove all components except the low frequency (10 Hz nominal) audio beat note. High drive level ($\geq$ +7 dBm) can be applied to both the LO and RF inputs to produce the largest beat note since IM products are not a concern.
6. Lower beat frequencies introduce problems with flicker noise and AC couplings. Higher beat frequencies provide less measurement resolution and a higher effective noise floor.
7. The IF sections follow the general approach of the JPL 1990 PTTI paper.
8. The first stage is a low noise precision linear amplifier that establishes the overall 16 Hz noise bandwidth and provides a sinusoidal IF output for test purposes. LT1028 devices are shown, but the LT1007 can be used instead and might provide lower noise at the 1 kΩ impedance level. Higher gain and lower noise would result by lowering the value of the R13 and R34 input resistors.
9. The second stage is a rail-to-rail precision amplifier that gracefully clips the audio beat note and increases its slew rate. Its input is AC-coupled to avoid zero-crossing detector dependence on the mixer DC output. Its feedback network includes a capacitor to roll off the gain to unity above 4 kHz. This stage shares power supply bypass capacitors with the first IF amplifier and comparator.
10. The final IF stage is a comparator operating as a zero-crossing detector that provides a TTL output signal for a time interval counter. The comparator has a small amount of hysteresis to avoid oscillation at its switching transitions. It is preceded by a 16 kHz low-pass filter to reduce the wideband noise. According to its data sheet, the AD8561 should operate properly with a rail-to-rail input since the other input remains within the specified common mode range.
11. The DMTD mixer module circuits operate from ±5V supplies derived from ±12V nominal external DC power with reverse polarity protection via series diodes. Separate ±5V regulators are provided for the reference and measurement sections. It might be a good idea to add noise filtration.
12. The noise floor is determined mainly by the amplitude noise at the input of the zero-crossing detector.
13. The phase stability is determined primarily by that of the input buffer amplifiers.
14. The system should be operated at a small time difference so as to minimize the noise contribution of the offset LO.
15. The DMTD mixer module should be evaluated for the RF and LO levels and IF amplifier gain and bandwidth settings that provide the best noise floor.
16. The use of phase averaging should be investigated as a means for further reducing the noise floor as a tradeoff against changing the noise characteristic from white to random walk PM noise.

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